PATENT ABSTRACTS OF JAPAN

(11)Publication number : 09-236834
(43)Date of publication of application : 09.09.1997

(51)Int.Cl. G02F 1/35
H04B 10/00

(21)Application number : 08-041940
(22)Date of filing : 28.02.1996

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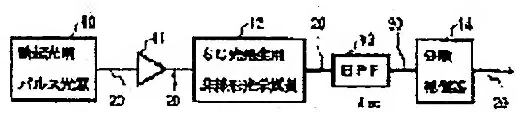
(54) LIGHT PULSE GENERATING CIRCUIT

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent polarization condition from being changed and to improve operational stability by using the components of all a polarization holding type and coupling all of these optical main axes in parallel or perpendicularly.
SOLUTION: A pulsed light source 10 which generates SC light pulses, an optical amplifier 11, a nonlinear optical medium 12, an optical band-pass filter 13 and a dispersion compensator 14 are defined as a polarization holding type, all optical axes of each component are coupled in parallel or perpendicular by an optical coupling means 20 of the polarization holding type. In this way, in the case using optical parts of optical fiber structure when respective elements are defined as the polarization holding type, the elements can be structured by ANDA fibers or elliptic core fibers. By this, changes in the polarization condition of output pulses and pulses can be made small for mechanical vibrations and temperature variation, etc. Since the components for controlling the conditions of polarization is unnecessitated the loss of the entire system can be reduced, and the device can be made small in size and low in cost.



LEGAL STATUS

[Date of request for examination]	26.10.1999
[Date of sending the examiner's decision of rejection]	25.06.2002
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3369833
[Date of registration]	15.11.2002

[Number of appeal against examiner's decision of rejection]	2002-014074
[Date of requesting appeal against examiner's decision of rejection]	25.07.2002
[Date of extinction of right]	

CLAIMS

[Claim(s)]
[Claim 1] The source of pulsed light which generates the light pulse of a predetermined repeat frequency, and the optical amplifier which amplifies said light pulse, the amplified light pulse — super KONTINIAMU (it is called "SC" below —) In the light pulse generator equipped with the nonlinear optics medium changed into a light pulse, the optical band pass filter which cuts off the predetermined wavelength region in the spectrum of said SC light pulse, and the distributed compensator with which the char ping of said SC light pulse is compensated The light pulse generator which uses said source of pulsed light, an optical amplifier, a nonlinear optics medium, an optical band pass filter, and a distributed compensator as a polarization maintenance mold, and is characterized by being the configuration which combined the whole of each optical main shaft with parallel or a rectangular cross.
[Claim 2] A light pulse generator according to claim 1 and the optical turnout which branches spatially SC light pulse outputted from said light pulse generator to N individual (N is two or more integers), The optical modulator of N individual which modulates the reinforcement or the phase of SC light pulse of said N individual by the predetermined signal, respectively, The optical delay machine of N individual which gives delay which is different on a time-axis, respectively to the light pulse signal of each channel, The light pulse generator which multiplexs the light pulse signal of an N channel, is equipped with the optical multiplexing machine outputted as a Time-Division-Multiplexing lightwave signal, uses said optical turnout, an optical modulator, an optical delay machine, and an optical multiplexing machine as a polarization maintenance mold, and is characterized by being the configuration which combined the whole of each optical main shaft with parallel or a rectangular cross.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the light pulse generator made to generate the high speed and ultrashort light pulse used for optical communication, or optical measurement and others.
[0002]
[Description of the Prior Art] It has been an important technical problem how implementation of ultra high-speed light measurement of ultra high-speed optical communication, an optical sampling, etc. can be made to generate a light pulse with it (380 bibliography: "the ultra high-speed light wave form measuring method by the optical sampling using sum cycle light generating" besides Takayoshi , the Institute of Electronics, Information and Communication Engineers paper magazine, B-I, vol.J75-B-I, No. 5, pp.372- 1992). . [narrow pulse width and] [stable]
[0003] There are combination of a ring resonator mold mode locked laser, a Fabry-Perot resonator mold mode locked laser, gain switching semiconductor laser, CW semiconductor laser, and an electroabsorption modulator and others in the conventional source of pulsed light. Drawing 4 shows the example of a configuration of the conventional ring resonator mold mode locked laser. In drawing, it is the optical amplifier with which 41 amplifies an optical modulator and 42 amplifies a light pulse, the optical band pass filter (BPF) with which 43 determines oscillation wavelength within the gain spectral band width of an optical amplifier, the optical turnout from which 44 takes out a part of light pulse (mode locked laser output light) outside, and the optical delay machine to which 45 carries out adjustable [of the optical path length], and they are combined in the shape of a ring through the optical coupling means 46, and a ring resonator is constituted. An oscillator 49 is connected to an optical modulator 41 through a voltage amplifier 48 with direct current voltage supply 47, and it is the frequency f0 of an oscillator 49. The loss or the phase of light which responds and spreads the inside of a ring resonator is modulated, and it is the repeat frequency f0. A light pulse train is generated.
[0004] It sets in the source of pulsed light of above others, and is the frequency f0 of an oscillator similarly. It responds and repeats and is a frequency f0. A light pulse train can be generated. However, the pulse width of such output light was more than the number ps. On the other hand, it is pulse width at the repeat frequency of 6GHz or more as a technique announced recently. There is an SC light pulse evolution method which generates the high speed and ultrashort light pulse of 0.5 or less pses (bibliography: T.Morioka et al., "Nearly penelty-free and 4 ps supercontinuum WDM pulsegeneration for Tbit/s TDM-WDM network", OFC94 and PD21, 1994). .
[0005] Drawing 5 shows the example of a configuration of the light pulse generator which used SC light pulse generating. In drawing, 50 is a source for excitation of pulsed light, and 51 is an optical amplifier and an optical coupling means by which an optical band pass filter (BPF) and 55 combine a distributed compensator, and, as for a polarization controller and 53, 56 combines each component for 52 optically, as for the nonlinear optics medium for SC light generating, and 54. A ring resonator mold mode locked laser as shown in drawing 4 is used for the source 50 for

excitation of pulsed light. A rare earth addition fiber is used for an optical amplifier 51. An optical fiber is used for the distributed compensator 55.

[0006] Hereafter, the generating process of SC light pulse is explained with reference to drawing 6 . The excitation light pulse outputted from the source 50 for excitation of pulsed light is amplified with an optical amplifier 51, and after being set as a predetermined polarization condition with the polarization controller 52, incidence of it is carried out to the nonlinear optics medium 53 for SC light generating (drawing 6 (a)). At this time, it is wavelength lambdaP of excitation light. It sets up so that the zero dispersive wave length of the nonlinear optics medium 53 for SC light generating may become near. and if it amplifies so that the peak power of excitation light may become high enough, the conversion to SC light pulse from an excitation light pulse will break out within the nonlinear optics medium 53 for SC light generating.

[0007] This SC light pulse is drawing 6 (b). It becomes a light pulse train with the spectral band width of an extensive wavelength region dozens of nm or more so that it may be shown. And SC light pulse of desired wavelength lambdaSC is cut off using the optical band pass filter 54 (drawing 6 (c)). When filtered SC light pulse has a char ping (optical frequency should differ in time within a light pulse) under the effect of the distributed property of the nonlinear optics medium 53 for SC light generating at this time, it changes into the light pulse train which controls this char ping by the distributed compensator 55, and does not have a char ping (drawing 6 (d)). In addition, when there is no char ping in SC light pulse in the cut-off spectral band width, the distributed compensator 55 is unnecessary.

[0008] The spectral band width of obtained SC light pulse is determined by the bandwidth of the optical band pass filter 54. When this bandwidth is set to deltaf and light pulse width of face is set to deltat, these products (time amount bandwidth product) are delta f-delta t>=C. -- It is set to (1) and becomes more than Fourier transform threshold value. Here, C is a value decided by the configuration of a light pulse, for example, in the case of a gauss mold, is C= 0.44 and sech2. In the case of a mold, it is set to C= 0.31. Especially, It is (1) type and a light pulse in case an equal sign is realized is called a Fourier transform marginal pulse.

[0009] When there is no char ping in SC light pulse, a Fourier transform marginal pulse is acquired. Therefore, light pulse width-of-face deltat of SC light pulse is deltat=C/deltaf. -- It turns out that it is set to (2) and a light pulse with narrow pulse width is obtained by increasing bandwidth deltaf. For example, if it is set as deltaf= 650GHz (wavelength of about 5nm) and a light pulse wave is assumed to be a gauss mold, pulse width deltat= 0.5ps will be obtained. Therefore, since the ultrashort light pulse of the pulse width of a sub picosecond can be obtained, this SC light pulse evolution method is hundreds Gbit/s. A communication link, optical sampling light wave form measurement of high time resolution, etc. are attained with a ultra high-speed light of a field.

[0010]

[Problem(s) to be Solved by the Invention] It is thought that generating of SC light pulse breaks out by compound of nonlinear optical effects, such as self-phase modulation which has the polarization dependency of incident light, 4 light-wave mixing, and the Raman magnification. Therefore, also in the configuration shown in drawing 5 , the generating effectiveness and the spectrum of SC light pulse change depending on the polarization condition of an excitation light pulse. Therefore, using the polarization controller 52, the polarization condition of the excitation light pulse after magnification was adjusted so that it might become the the best for SC light pulse generating.

[0011] By the way, with the configuration, the optical fiber (it is 1km or more at an optical amplifier with 10m or more and the nonlinear optics medium for SC light generating) of the long picture which does not hold polarization as an optical amplifier 51 or a nonlinear optics medium 53 for SC light generating is used conventionally which is shown in drawing 5 . Therefore, though the light pulse by which the polarization condition was stabilized from the source 50 for excitation of pulsed light is generated, change of a polarization condition tends to break out inside an optical fiber under a mechanical vibration or the effect of a temperature change. Moreover, since the optical band pass filter 54, the distributed compensator 55, and the optical coupling means 56 were not polarization maintenance molds, either, there was a trouble that the

polarization condition of SC light pulse changed in time also after SC light pulse generating.
[0012] In the optical communication mentioned above or the field of optical measurement, an optical modulator, an optical gate component, etc. with a polarization dependency are used in many cases. Therefore, since it was easy to produce level variation, a polarization change of state, etc. of SC light pulse by external fluctuation, the light pulse generator using the conventional SC light pulse generating was difficult for actually applying. This invention aims at offering the light pulse generator which can prevent change of the polarization condition of SC light pulse by external fluctuation in the configuration which generates SC light pulse.
[0013]
[Means for Solving the Problem] The light pulse generator of claim 1 is the configuration which used as the polarization maintenance mold the source of pulsed light and optical amplifier which generate SC light pulse, the nonlinear optics medium, the optical band pass filter, and the distributed compensator, and combined all of these optical main shafts with parallel or a rectangular cross. Thus, by using each component of a light pulse generator as a polarization maintenance mold, change of a polarization condition can be prevented and stability of operation can be raised.
[0014] The light pulse generator of claim 2 branches SC light pulse in several channel minutes, modulates each SC light pulse by signal, respectively, in the configuration delay which is different to each light pulse signal, respectively is given [configuration], and it multiplexs [configuration], uses each component as a polarization maintenance mold, and combines all optical main shafts with parallel or a rectangular cross. Thereby, change of a polarization condition can be prevented in the process of Time Division Multiplexing of a light pulse signal, and stability of operation can be raised.
[0015]
[Embodiment of the Invention] Drawing 1 shows the operation gestalt of the light pulse generator of claim 1. In drawing, the source for excitation of pulsed light where 10 generates the light pulse of single polarization, and 11 are the optical amplifier of a polarization maintenance mold, and an optical-coupling means of a polarization maintenance mold to by_which in the nonlinear optics medium for SC light generating of a polarization maintenance mold, and 13 the optical band pass filter (BPF) of a polarization maintenance mold and 14 combine with the distributed compensator of a polarization maintenance mold, and 20 combines [12] the optical main shaft of each component with parallel or a rectangular cross altogether.
[0016] The quartz system optical waveguide of the optical amplifier using the rare earth addition fiber as an optical amplifier 11 of a polarization maintenance mold, a semiconductor laser amplifier, and the planar mold that carried out rare earth addition can be used. As a nonlinear optics medium 12 for SC light generating of a polarization maintenance mold, an optical fiber, semiconductor waveguide, an organic crystal, or organic waveguide can be used. As a distributed compensator 14 of a polarization maintenance mold, an optical fiber, the quartz system optical waveguide of a planar mold, semiconductor waveguide, a diffraction-grating pair, a prism pair, a Gires-Tournois interference system, and a fiber grating can be used.
[0017] What is necessary is here, just to make it a PANDA fiber and an ellipse core fiber configuration, in using the optical components of optical fiber structure, when using as a polarization maintenance mold each element which constitutes a light pulse generator. Moreover, since these are form birefringence ingredients and have already had polarization holdout in using components and components, such as quartz system optical waveguide of a planar mold, a semi-conductor, and a crystal, it can use as it is.
[0018] Moreover, what is necessary is just to transpose a component part and a component to polarization maintenance molds, such as a PANDA fiber, an ellipse core fiber, quartz system optical waveguide of a planar mold, semiconductor waveguide, and a crystal, in the combination of the above-mentioned ring resonator mold mode locked laser, a Fabry-Perot resonator mold mode locked laser, gain switching semiconductor laser, CW semiconductor laser, and an electroabsorption modulator, and other configurations, in order to generate the light pulse of single polarization in the source 10 for excitation of pulsed light.
[0019] Furthermore, all of the optical main shaft of these components are combined with parallel

or a rectangular cross. Thereby, since the polarization direction of the light pulse in equipment does not change with external fluctuation but a guided wave is held and carried out in the same polarization direction, the unstable actuation by change of a polarization condition does not break out. Moreover, since the polarization controller needed conventionally becomes unnecessary, the loss is also cancelable while a configuration becomes easy.

[0020] Drawing 2 shows the operation gestalt of the light pulse generator of claim 2. In drawing, 10-14 are the same as that of the 1st operation gestalt. However, the optical amplifier of the polarization maintenance mold with which 11-1 is arranged at the preceding paragraph of the nonlinear optics medium 12 for SC light generating, and 11-2 are the optical amplifiers of the polarization maintenance mold arranged in the latter part of the distributed compensator 14. With this operation gestalt, the Time-Division-Multiplexing section 19 further constituted with the optical multiplexing vessel 18 of the optical turnout 15 of a polarization maintenance mold, the optical modulator 16-1 of a polarization maintenance mold - 16-N, the optical delay machine 17-1 of a polarization maintenance mold - 17-N, and a polarization maintenance mold is connected.

[0021] As the optical turnout 15 and the optical multiplexing machine 18 of a polarization maintenance mold, the optical fiber mold coupler which consists of a PANDA fiber or an ellipse core fiber can be used. as the optical modulator 16 of a polarization maintenance mold -- LiNbO3 etc. -- the optical modulator using an electro-optical effect ingredient, an electric-field absorption mold semi-conductor modulator, etc. can be used. As an optical delay machine 17 of a polarization maintenance mold, a PANDA fiber and an ellipse core fiber can be used and the time amount spread with the die length is adjusted. Moreover, what was formed on the quartz system optical waveguide of a planar mold may be used for the optical turnout 15, the optical delay machine 17, and the optical multiplexing machine 18.

[0022] Drawing 3 shows the example of the Time-Division-Multiplexing section 19 of operation. N division is carried out, by the optical modulator 16-1 - 16-N, reinforcement or a phase is modulated and SC light pulse inputted into the optical turnout 15 from the optical amplifier 11-2 is encoded independently, respectively. Then, delay which is different by the optical delay machine 17-1 - 17-N, respectively is given so that the lightwave signal of an N channel may not lap on a time-axis (drawing 3 (a) - (c)). By multiplexing these lightwave signals with the optical multiplexing vessel 18, Time Division Multiplexing of the lightwave signal of an N channel can be carried out (drawing 3 (d)).

[0023] With the configuration of this invention, all components are used as a polarization maintenance mold, and all of these optical main shafts are combined with parallel or a rectangular cross. Therefore, since the polarization direction of the light pulse in equipment does not change with external fluctuation but a guided wave is held and carried out in the same polarization direction, the stable Time-Division-Multiplexing lightwave signal of single polarization can be acquired.

[0024]

[Effect of the Invention] As explained above, the light pulse generator of this invention can make small the polarization condition of an output light pulse, and change of level to mechanical oscillation, temperature fluctuation, etc. by using all components as a polarization maintenance mold, and combining all optical main shafts with parallel or a rectangular cross further. Moreover, since the component for controlling a polarization condition becomes unnecessary, loss of the whole system can be reduced and miniaturization and low cost-ization can be attained.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Field of the Invention] This invention relates to the light pulse generator made to generate the high speed and ultrashort light pulse used for optical communication, or optical measurement and others.

[Translation done.]

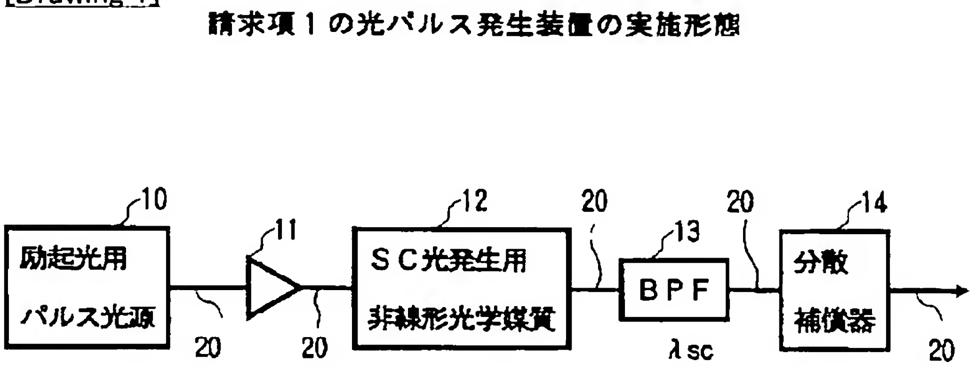
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The block diagram showing the operation gestalt of the light pulse generator of claim 1.
[Drawing 2] The block diagram showing the operation gestalt of the light pulse generator of claim 2.
[Drawing 3] Drawing showing the example of the Time-Division-Multiplexing section 19 of operation.
[Drawing 4] The block diagram showing the example of a configuration of the conventional ring resonator mold mode locked laser.
[Drawing 5] The block diagram showing the example of a configuration of the light pulse generator using SC light pulse generating.
[Drawing 6] Drawing explaining the generating process of SC light pulse.
[Description of Notations]
10 Source for Excitation Light of Single Polarization of Pulsed Light
11 Optical Amplifier of Polarization Maintenance Mold
12 Nonlinear Optics Medium for SC Light Generating of Polarization Maintenance Mold
13 Optical Band Pass Filter of Polarization Maintenance Mold (BPF)
14 Distributed Compensator of Polarization Maintenance Mold
15 Optical Turnout of Polarization Maintenance Mold
16 Optical Modulator of Polarization Maintenance Mold
17 Optical Delay Machine of Polarization Maintenance Mold
18 Optical Multiplexing Machine of Polarization Maintenance Mold
20 Optical Coupling Means of Polarization Maintenance Mold
50 Source for Excitation Light of Pulsed Light
51 Optical Amplifier
52 Polarization Controller
53 Nonlinear Optics Medium for SC Light Generating
54 Optical Band Pass Filter (BPF)
55 Distributed Compensator
56 Optical Coupling Means

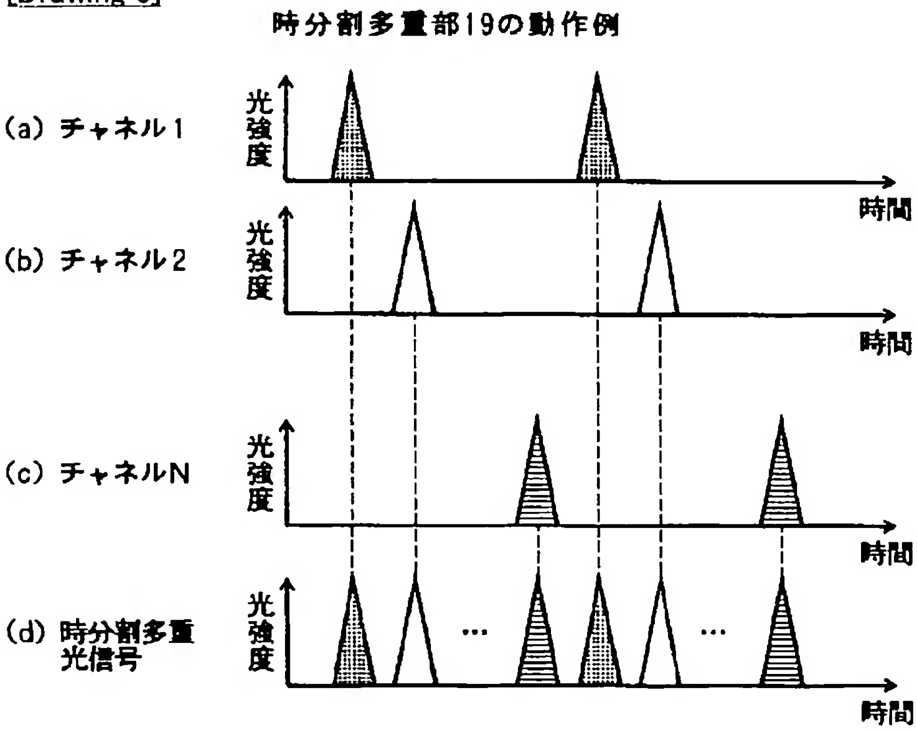
[Translation done.]

DRAWINGS

[Drawing 1]

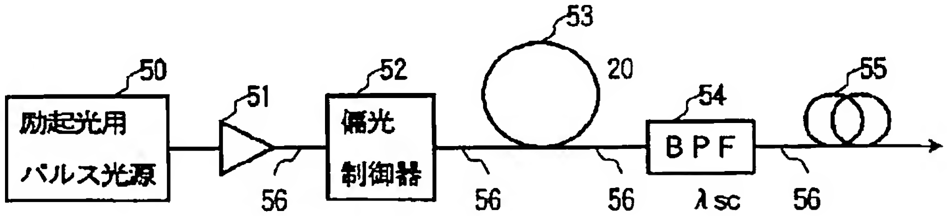


[Drawing 3]



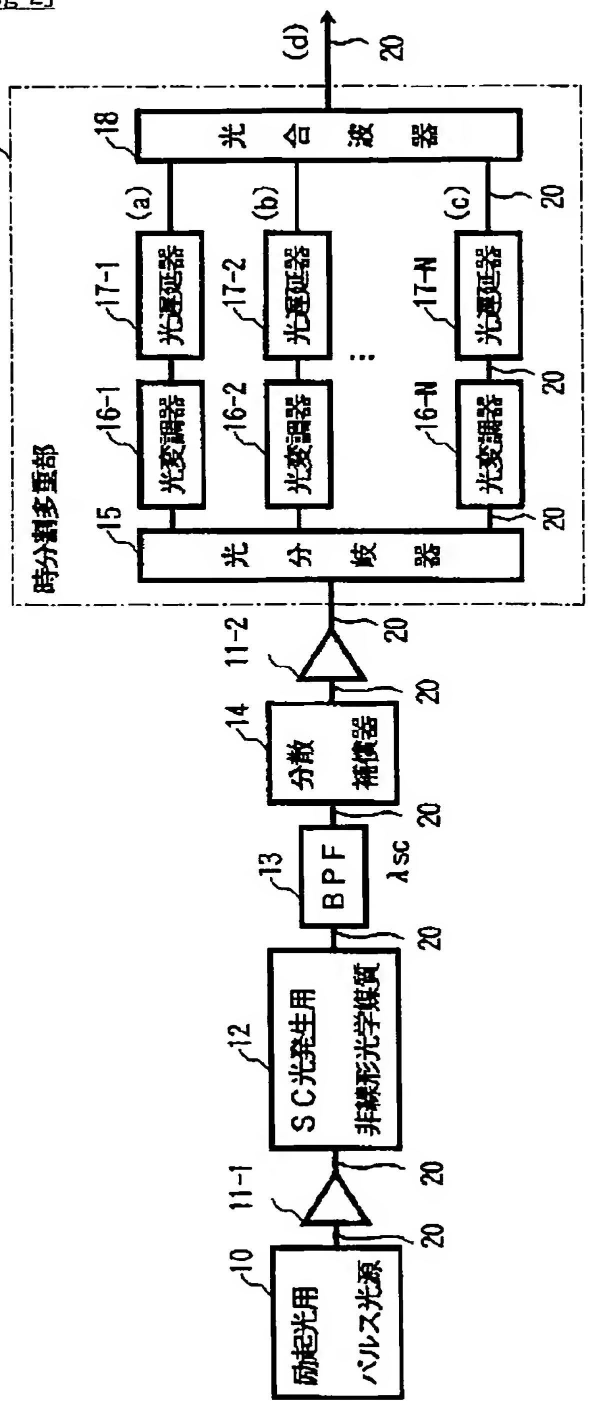
[Drawing 5]

ＳＣ光パルス発生を用いた光パルス発生装置の構成例



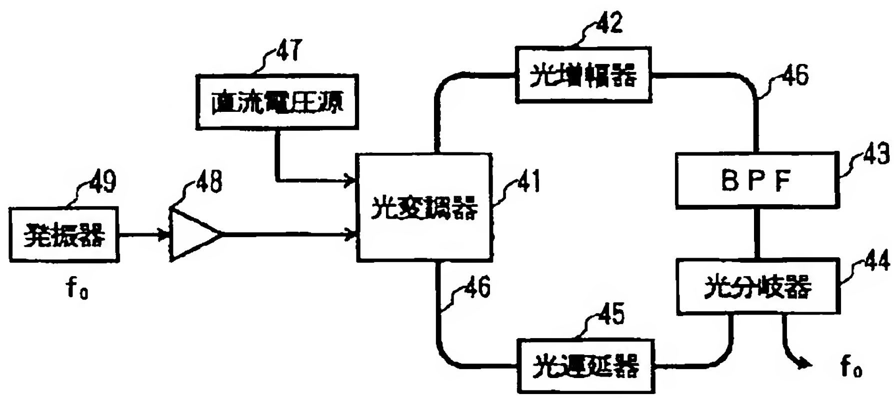
[Drawing 2]

請求項２の光パルス発生装置の実施形態



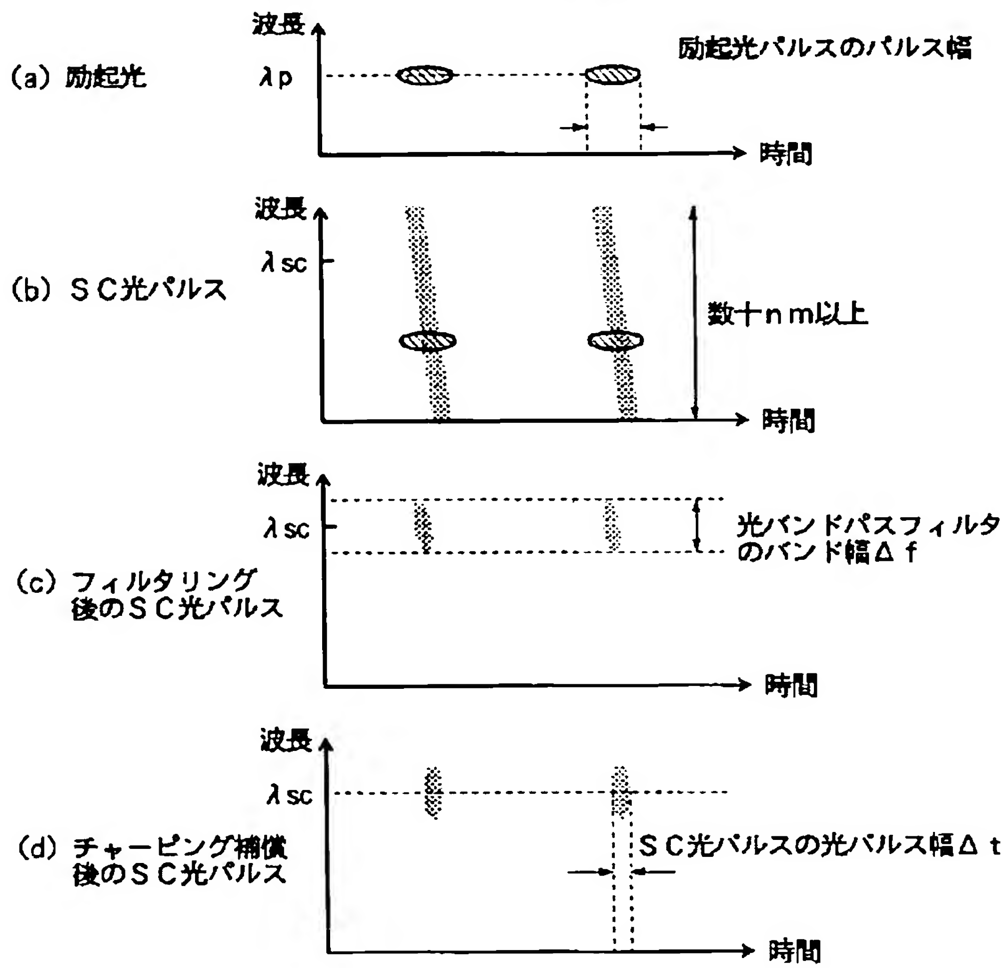
[Drawing 4]

従来のリング共振器型モード同期レーザの構成例



[Drawing 6]

SC光パルスの発生過程



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平9－236834

(43)公開日　平成9年(1997)9月9日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｆ　1/35			Ｇ０２Ｆ　1/35	
Ｈ０４Ｂ　10/00			Ｈ０４Ｂ　9/00	Ｚ

審査請求　未請求　請求項の数２　ＯＬ　（全 ７ 頁）

(21)出願番号　特願平8－41940

(22)出願日　平成8年(1996)2月28日

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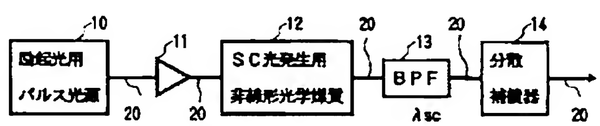
(54)【発明の名称】　光パルス発生装置

(57)【要約】

【課題】　外部変動によるＳＣ光パルスの偏光状態の変化を防ぐ。

【解決手段】　ＳＣ光パルスを発生するパルス光源、光増幅器、非線形光学媒質、光バンドパスフィルタ、分散補償器が、光パルスの偏光方向を保持し、これらの光学主軸をすべて平行または直交に結合する。

請求項１の光パルス発生装置の実施形態



【特許請求の範囲】

【請求項１】　所定の繰り返し周波数の光パルスを発生するパルス光源と、前記光パルスを増幅する光増幅器と、
増幅された光パルスをスーパーコンティニアム（以下「ＳＣ」という。）光パルスに変換する非線形光学媒質と、
前記ＳＣ光パルスのスペクトル中の所定の波長域を切り取る光バンドパスフィルタと、
前記ＳＣ光パルスのチャーピングを補償する分散補償器とを備えた光パルス発生装置において、
前記パルス光源、光増幅器、非線形光学媒質、光バンドパスフィルタ、分散補償器を偏光保持型とし、それぞれの光学主軸をすべて平行または直交に結合した構成であることを特徴とする光パルス発生装置。

【請求項２】　請求項１に記載の光パルス発生装置と、前記光パルス発生装置から出力されるＳＣ光パルスを空間的にＮ個（Ｎは２以上の整数）に分岐する光分岐器と、
前記Ｎ個のＳＣ光パルスの強度または位相をそれぞれ所定の信号で変調するＮ個の光変調器と、
各チャネルの光パルス信号に時間軸上でそれぞれ異なる遅延を与えるＮ個の光遅延器と、
Ｎチャネルの光パルス信号を合波し、時分割多重光信号として出力する光合波器とを備え、前記光分岐器、光変調器、光遅延器、光合波器を偏光保持型とし、それぞれの光学主軸をすべて平行または直交に結合した構成であることを特徴とする光パルス発生装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光通信や光計測その他に用いる高速・超短光パルスを発生させる光パルス発生装置に関する。

【０００２】

【従来の技術】超高速光通信や光サンプリング等の超高速光計測の実現には、いかにパルス幅が狭く安定な光パルスを発生させることができるかが重要な課題になっている（参考文献：高良　他，「和周波光発生を用いた光サンプリングによる超高速光波形測定法」，電子情報通信学会論文誌，B-I，vol.J75-B-I，No.5，pp.372-380.1992）。

【０００３】従来のパルス光源には、リング共振器型モード同期レーザ、ファブリペロー共振器型モード同期レーザ、利得スイッチング半導体レーザ、ＣＷ半導体レーザと電界吸収型光変調器の組み合わせ、その他がある。図４は、従来のリング共振器型モード同期レーザの構成例を示す。図において、４１は光変調器、４２は光パルスを増幅する光増幅器、４３は発振波長を光増幅器の利得スペクトル幅内で決定する光バンドパスフィルタ（ＢＰＦ）、４４は光パルス（モード同期レーザ出力光）の

一部を外部に取り出す光分岐器、４５は光路長を可変させる光遅延器であり、それらが光結合手段４６を介してリング状に結合されリング共振器が構成される。光変調器４１には、直流電圧源４７と、電圧増幅器４８を介して発振器４９が接続され、発振器４９の周波数 f_0 に応じてリング共振器内を伝搬する光の損失あるいは位相を変調し、繰り返し周波数 f_0 の光パルス列を発生させる。

【０００４】上記のその他のパルス光源においても、同様に発振器の周波数 f_0 に応じて繰り返し周波数 f_0 の光パルス列を発生させることができる。しかし、これらの出力光のパルス幅は数ｐｓ以上であった。一方、最近発表された技術として、繰り返し周波数６GHz以上でパルス幅 0.5ｐｓ以下の高速・超短光パルスを発生させるＳＣ光パルス発生法がある（参考文献：T.Morioka et al.，"Nearly penelty-free, 4ps supercontinuum WDM pulsegeneration for Tbit/s TDM-WDM network"，OFC94，PD21，1994）。

【０００５】図５は、ＳＣ光パルス発生を用いた光パルス発生装置の構成例を示す。図において、５０は励起用パルス光源、５１は光増幅器、５２は偏光制御器、５３はＳＣ光発生用非線形光学媒質、５４は光バンドパスフィルタ（ＢＰＦ）、５５は分散補償器、５６は各構成要素を光学的に結合する光結合手段である。励起用パルス光源５０には、例えば図４に示すようなリング共振器型モード同期レーザが用いられる。光増幅器５１には希土類添加ファイバが用いられる。分散補償器５５には光ファイバが用いられる。

【０００６】以下、図６を参照してＳＣ光パルスの発生過程について説明する。励起用パルス光源５０から出力された励起光パルスは、光増幅器５１で増幅され、偏光制御器５２で所定の偏光状態に設定された後にＳＣ光発生用非線形光学媒質５３に入射される（図６(a)）。このとき、励起光の波長 λ_P とＳＣ光発生用非線形光学媒質５３の零分散波長が近くなるように設定し、励起光のピークパワーが十分に高くなるように増幅すると、ＳＣ光発生用非線形光学媒質５３内で励起光パルスからＳＣ光パルスへの変換が起きる。

【０００７】このＳＣ光パルスは図６(b) に示すように、数十ｎｍ以上の広波長域のスペクトル幅を有した光パルス列となる。そして、光バンドパスフィルタ５４を用いて所望の波長 λ_{sc} のＳＣ光パルスを切り取る（図６(c)）。このとき、フィルタリングしたＳＣ光パルスがＳＣ光発生用非線形光学媒質５３の分散特性の影響でチャーピング（光パルス内で時間的に光周波数が異なること）を有する場合には、分散補償器５５でこのチャーピングを制御してチャーピングのない光パルス列に変換する（図６(d)）。なお、切り取ったスペクトルバンド幅内のＳＣ光パルスにチャーピングがない場合には分散補償器５５は不要である。

【０００８】得られたＳＣ光パルスのスペクトルバンド幅は、光バンドパスフィルタ５４のバンド幅によって決定される。このバンド幅をΔｆ、光パルス幅をΔｔとすると、これらの積（時間バンド幅積）は、

$\Delta f \cdot \Delta t \geqq C$　　　…(1)

となり、フーリエ変換限界値以上となる。ここで、Ｃは光パルスの形状で決まる値であり、例えばガウス型の場合にはＣ＝0.44、sech^2 型の場合にはＣ＝0.31となる。特に、(1)式で等号が成り立つ場合の光パルスをフーリエ変換限界パルスと呼ぶ。

【０００９】ＳＣ光パルスにチャーピングがない場合にはフーリエ変換限界パルスが得られる。したがって、ＳＣ光パルスの光パルス幅Δｔは、

$\Delta t = C / \Delta f$　　　…(2)

となり、バンド幅Δｆを増加することによりパルス幅の狭い光パルスが得られることがわかる。例えば、Δｆ＝650ＧHz（波長約５ｎｍ）に設定し、光パルス波形をガウス型と仮定すると、パルス幅Δｔ＝ 0.5ｐｓが得られる。したがって、このＳＣ光パルス発生法は、サブピコ秒のパルス幅の超短光パルスを得ることができるので、数百Ｇbit/s 領域の超高速光で通信および高時間分解能の光サンプリング光波形測定などが可能となる。

【００１０】

【発明が解決しようとする課題】ＳＣ光パルスの発生は、入射光の偏光依存性を有する自己位相変調、４光波混合、ラマン増幅等の非線形光学効果の複合により起きると考えられている。したがって、図５に示す構成においても励起光パルスの偏光状態に依存してＳＣ光パルスの発生効率やスペクトルが変化する。そのため、偏光制御器５２を用いて増幅後の励起光パルスの偏光状態をＳＣ光パルス発生に最適になるように調整していた。

【００１１】ところで、図５に示す従来構成では、光増幅器５１やＳＣ光発生用非線形光学媒質５３として偏光を保持しない長尺の光ファイバ（光増幅器で10ｍ以上、ＳＣ光発生用非線形光学媒質で１ｋｍ以上）が用いられている。したがって、励起用パルス光源５０から偏光状態の安定した光パルスを発生させたとしても、機械的な振動や温度変化の影響により光ファイバ内部で偏光状態の変化が起きやすい。また、光バンドパスフィルタ５４、分散補償器５５、光結合手段５６も偏光保持型ではないので、ＳＣ光パルス発生後でもＳＣ光パルスの偏光状態が時間的に変化する問題点があった。

【００１２】上述した光通信や光計測の分野では、偏光依存性のある光変調器や光ゲート素子等を利用する場合が多い。したがって、従来のＳＣ光パルス発生を利用した光パルス発生装置は、外部変動によりＳＣ光パルスのレベル変動や偏光状態変化等が生じやすいために、実際に適用することは困難であった。本発明は、ＳＣ光パルスを発生させる構成において、外部変動によるＳＣ光パルスの偏光状態の変化を防ぐことができる光パルス発生装置を提供することを目的とする。

【００１３】

【課題を解決するための手段】請求項１の光パルス発生装置は、ＳＣ光パルスを発生するパルス光源、光増幅器、非線形光学媒質、光バンドパスフィルタ、分散補償器を偏光保持型とし、これらの光学主軸をすべて平行または直交に結合した構成である。このように光パルス発生装置の各構成要素を偏光保持型とすることにより、偏光状態の変化を防ぎ、動作の安定性を向上させることができる。

【００１４】請求項２の光パルス発生装置は、ＳＣ光パルスをチャネル数分に分岐し、各ＳＣ光パルスをそれぞれ信号で変調し、各光パルス信号にそれぞれ異なる遅延を与えて合波する構成において、各構成要素を偏光保持型とし光学主軸をすべて平行または直交に結合する。これにより、光パルス信号の時分割多重の過程において偏光状態の変化を防ぎ、動作の安定性を向上させることができる。

【００１５】

【発明の実施の形態】図１は、請求項１の光パルス発生装置の実施形態を示す。図において、１０は単一偏光の光パルスを発生する励起用パルス光源、１１は偏光保持型の光増幅器、１２は偏光保持型のＳＣ光発生用非線形光学媒質、１３は偏光保持型の光バンドパスフィルタ（ＢＰＦ）、１４は偏光保持型の分散補償器、２０は各構成要素の光学主軸をすべて平行または直交に結合する偏光保持型の光結合手段である。

【００１６】偏光保持型の光増幅器１１としては、希土類添加ファイバを用いた光増幅器、半導体レーザ増幅器、希土類添加したプレーナ型の石英系光導波路を利用できる。偏光保持型のＳＣ光発生用非線形光学媒質１２としては、光ファイバ、半導体導波路、有機結晶または有機導波路が使用できる。偏光保持型の分散補償器１４としては、光ファイバ、プレーナ型の石英系光導波路、半導体導波路、回折格子対、プリズム対、Gires-Tournois干渉系、ファイバグレーティングが使用できる。

【００１７】ここで、光パルス発生装置を構成する各要素を偏光保持型とするときに、光ファイバ構造の光部品を用いる場合には、ＰＡＮＤＡファイバや楕円コアファイバ構成にすればよい。また、プレーナ型の石英系光導波路、半導体、結晶等の部品や素子を用いる場合には、これらが複屈折性材料でありすでに偏光保持性を有しているので、そのまま用いることができる。

【００１８】また、励起用パルス光源１０において単一偏光の光パルスを発生させるには、上記のリング共振器型モード同期レーザ、ファブリペロー共振器型モード同期レーザ、利得スイッチング半導体レーザ、ＣＷ半導体レーザと電界吸収型光変調器の組み合わせ、その他の構成において、構成部品や素子をＰＡＮＤＡファイバ、楕円コアファイバ、プレーナ型の石英系光導波路、半導体

導波路、結晶等の偏光保持型に置き換えればよい。

【００１９】さらに、これらの構成要素の光学主軸をすべて平行または直交に結合する。これにより、装置内の光パルスの偏光方向は外部変動により変化せず、同一偏光方向に保持されて導波されるので、偏光状態の変化による不安定動作は起きない。また、従来必要とされていた偏光制御器が不要となるので、構成が簡単になるとともにその損失も解消できる。

【００２０】図２は、請求項２の光パルス発生装置の実施形態を示す。図において、１０～１４は第１の実施形態と同様である。ただし、１１－１はＳＣ光発生用非線形光学媒質１２の前段に配置される偏光保持型の光増幅器、１１－２は分散補償器１４の後段に配置される偏光保持型の光増幅器である。本実施形態では、さらに偏光保持型の光分岐器１５、偏光保持型の光変調器１６－１～１６－Ｎ、偏光保持型の光遅延器１７－１～１７－Ｎ、偏光保持型の光合波器１８により構成される時分割多重部１９が接続される。

【００２１】偏光保持型の光分岐器１５および光合波器１８としては、ＰＡＮＤＡファイバや楕円コアファイバからなる光ファイバ型カプラを使用できる。偏光保持型の光変調器１６としては、$LiNbO_3$ 等の電気光学効果材料を用いた光変調器や、電界吸収型半導体変調器などが利用できる。偏光保持型の光遅延器１７としては、ＰＡＮＤＡファイバや楕円コアファイバを使用でき、その長さにより伝搬する時間を調整する。また、光分岐器１５、光遅延器１７、光合波器１８は、プレーナ型の石英系光導波路上に形成したものを用いてもよい。

【００２２】図３は、時分割多重部１９の動作例を示す。光増幅器１１－２から光分岐器１５に入力されたＳＣ光パルスはN分割され、それぞれ光変調器１６－１～１６－Ｎで強度または位相が変調され、独立に符号化される。その後、Ｎチャネルの光信号が時間軸上で重ならないように、光遅延器１７－１～１７－Ｎでそれぞれ異なる遅延を与える（図３(a)～(c)）。これらの光信号を光合波器１８で合波することにより、Ｎチャネルの光信号を時分割多重することができる（図３(d)）。

【００２３】本発明の構成では、構成要素をすべて偏光保持型とし、これらの光学主軸をすべて平行または直交に結合する。したがって、装置内の光パルスの偏光方向は外部変動により変化せず、同一偏光方向に保持されて導波されるので、単一偏波の安定な時分割多重光信号を得ることができる。

【００２４】

【発明の効果】以上説明したように、本発明の光パルス発生装置は、構成要素をすべて偏光保持型とし、さらに光学主軸をすべて平行または直交に結合することにより、機械的振動や温度変動等に対して出力光パルスの偏光状態およびレベルの変化を小さくすることができる。また、偏光状態を制御するための構成要素が不要となるので、系全体の損失を低減することができ、小型化および低コスト化を図ることができる。

【図面の簡単な説明】

【図１】請求項１の光パルス発生装置の実施形態を示すブロック図。

【図２】請求項２の光パルス発生装置の実施形態を示すブロック図。

【図３】時分割多重部１９の動作例を示す図。

【図４】従来のリング共振器型モード同期レーザの構成例を示すブロック図。

【図５】ＳＣ光パルス発生を用いた光パルス発生装置の構成例を示すブロック図。

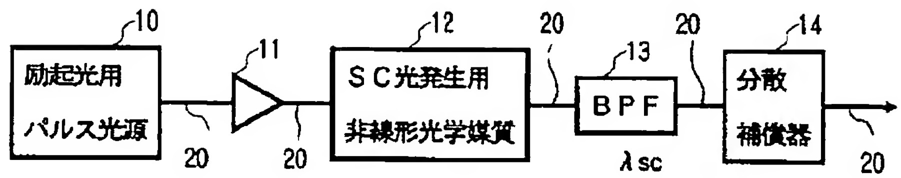
【図６】ＳＣ光パルスの発生過程を説明する図。

【符号の説明】

１０　単一偏光の励起光用パルス光源
１１　偏光保持型の光増幅器
１２　偏光保持型のＳＣ光発生用非線形光学媒質
１３　偏光保持型の光バンドパスフィルタ（ＢＰＦ）
１４　偏光保持型の分散補償器
１５　偏光保持型の光分岐器
１６　偏光保持型の光変調器
１７　偏光保持型の光遅延器
１８　偏光保持型の光合波器
２０　偏光保持型の光結合手段
５０　励起光用パルス光源
５１　光増幅器
５２　偏光制御器
５３　ＳＣ光発生用非線形光学媒質
５４　光バンドパスフィルタ（ＢＰＦ）
５５　分散補償器
５６　光結合手段

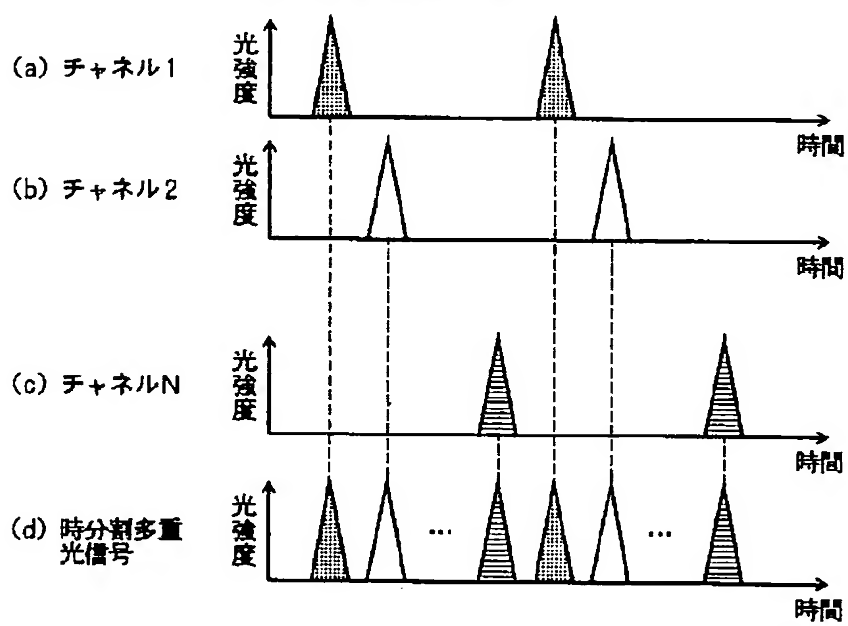
【図１】

請求項１の光パルス発生装置の実施形態



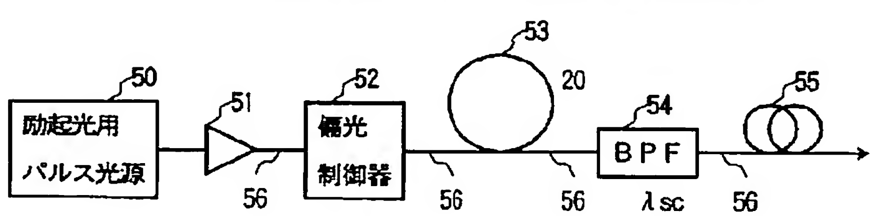
【図３】

時分割多重部19の動作例

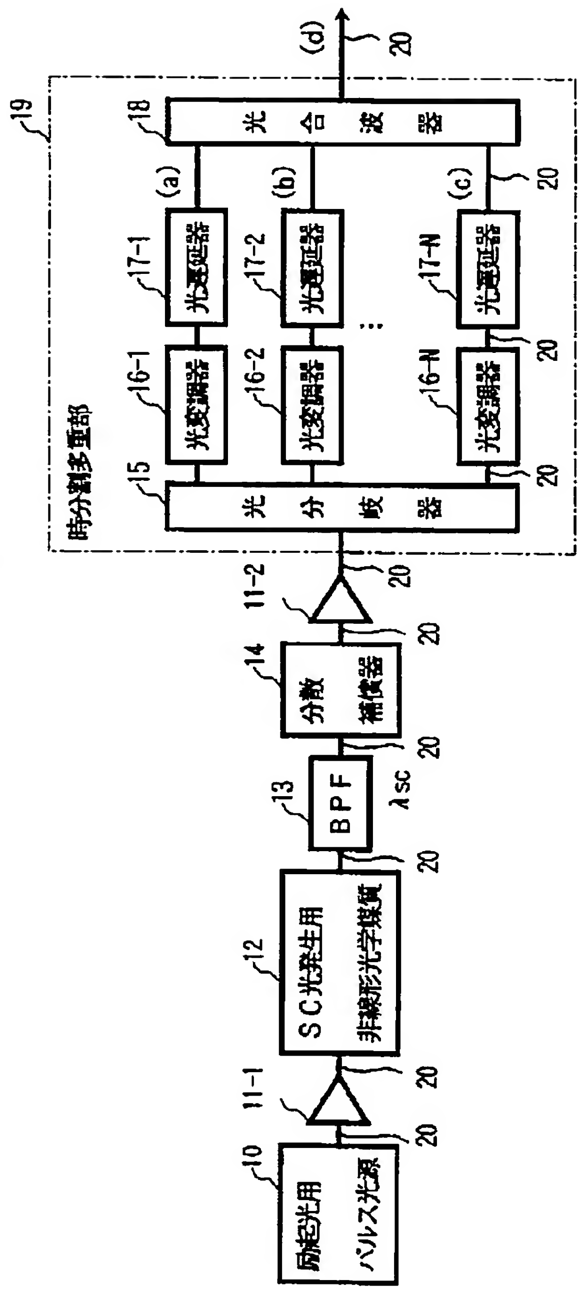


【図５】

ＳＣ光パルス発生を用いた光パルス発生装置の構成例



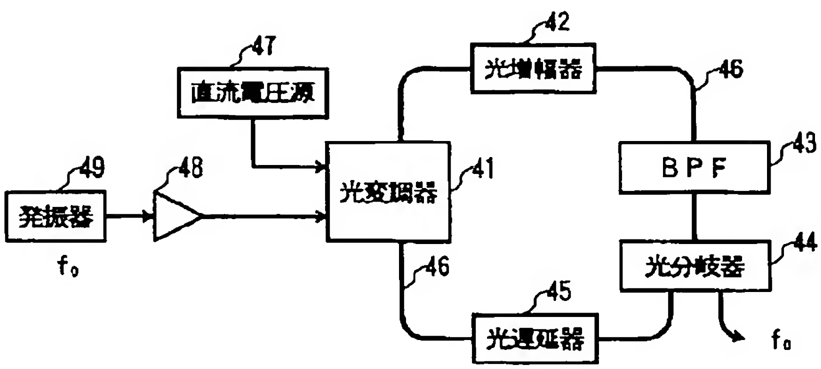
【図２】



請求項２の光パルス発生装置の実施形態

【図4】

従来のリング共振器型モード同期レーザの構成例



【図6】

SC光パルスの発生過程